Increasing diagnostic confidence and reducing radiation dose in PAE using Cone Beam CT based planning and guidance solutions

By Francisco Cesar Carnevale, MD, PhD*

“One of the main challenges in PAE is the identification of the prostatic arteries, including its origins and connections to surrounding organs. With Cone beam CT (CBCT) acquisition and segmentation techniques we are now able to correctly assess the prostatic vascularization, increasing diagnostic confidence. This also helps avoiding repeated DSA imaging, reducing use of contrast media and radiation exposure to patients and interventional team.”

Francisco Cesar Carnevale is Professor at the Hospital das Clinicas da Faculdade de Medicina at University of Sao Paulo Medical School, Chief of the Section for Interventional Vascular Radiology, former President of Brazilian Society of Interventional Radiology and the pioneer of the PAE procedure.

About the Institution: Hospital das Clinicas Complex has a total area of 600 thousand square meters with about 2,400 beds between its eight specialized institutes and 2 Hospitals. “Pride in Doing Best for People, with People” is the commitment and the reason why every member of the Institution devotes their efforts day after day.

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Benign Prostatic Hyperplasia (BPH) is one of the most common diseases in men over 50 years of age. Prostate Artery Embolisation (PAE) is a minimally invasive procedure that has emerged as an alternative treatment for surgery to treat BPH. It is a non-surgical X-ray guided procedure aiming at blocking off the arteries supplying the prostate and making it shrink. We asked Pr Francisco Cesar Carnevale, an interventional radiology expert who heads the section for interventional vascular radiology at the Hospital das Clinicas da Faculdade de Medicina at University of Sao Paulo Medical School, to share his thoughts regarding PAE technique and the evolution of this procedure.

How does PAE technique emerge?

Pr Francisco Cesar Carnevale: *“PAE was introduced into clinical practice as an alternative of treatment for lower urinary tract symptoms (LUTS) due to BPH in June 2008 after a successful experimental study in dogs in 2007. A pilot study[1] including two patients suffering from urinary retention with high risk for traditional surgery (transurethral resection of the prostate - TURP) due to several comorbidities were treated. Patients had the Foley catheter removed, symptoms relief and improved quality of life after PAE.”*

How many PAE procedures have you performed so far?

Pr Francisco Cesar Carnevale: “We have performed about 500 procedures since we performed the world first PAE in a patient with BPH in June 2008.”

What are the main challenges of this procedure?

Pr Francisco Cesar Carnevale: *“The biggest challenge is the identification of the prostatic arteries including their origin and potential connections with other anatomical structures like the rectum, penis and bladder. Another big challenge is the superselective catheterization of the prostatic arteries and the placement of the microcatheter in the most appropriate position. It is crucial to fully understand the anatomical region being fed by the catheterized artery to avoid non target embolizations. In many patients, we identified, and had to catheterize several prostatic arteries and shunts, making the procedure even more challenging.”*

What would be the ideal imaging solution?

Pr Francisco Cesar Carnevale: *“The ideal imaging solution would help to identify these arteries, with a minimal amount of angiographic acquisitions, help guide the microcatheter to the right position, and confirm the prostate territory that would be embolized from this position, in order to limit risks of non-targeted embolization and achieve better technical and clinical results.”*

Why is a training program crucial to become efficient in this practice?

Pr Francisco Cesar Carnevale: *“It is key to practice and share our experience with the community. Training programs aid physicians to achieve good clinical success while minimizing risks of complications. Our institution’s training program includes theoretical and practical sessions through the use of simulators and live cases performed under proctor supervision. After theoretical and edited cases and playing with PAE cases in simulators, physicians are able to scrub and actively participate during the live cases. They can use microwires and microcatheters experiencing our recognized PErFecTED[2] (Proximal Embolization First, Then Embolize Distal) technique. It’s an amazing experience for everyone.”*

Can you describe the importance of the PErFecTED technique?

Pr Francisco Cesar Carnevale: *"The PErFecTED embolization technique has been developed in our institution. Medium and long-term follow-up in different centers worldwide using this technique have demonstrated better clinical and imaging results, both in terms of symptoms and quality of life, as well as higher incidence of prostate infarcts with volume reduction and lower rate of symptoms recurrence at long-term follow-up."*

How do you envision the evolution of PAE?

Pr Francisco Cesar Carnevale: *"After celebrating the 10th anniversary, PAE is now recognized as an alternative treatment for patients suffering from LUTS originating from BPH. It has been demonstrated to be safe and efficient[3] to treat different BPH-related symptoms. However, there are different areas of research with the aim to identify the best candidate for PAE as well improve its technical aspects. There's a huge opportunity for physicians and companies explore the field of PAE trying to understand the patient's expectation. We have an international collaboration team working hard in this field of innovation and new tools will help physicians to bring alternatives for patients."*

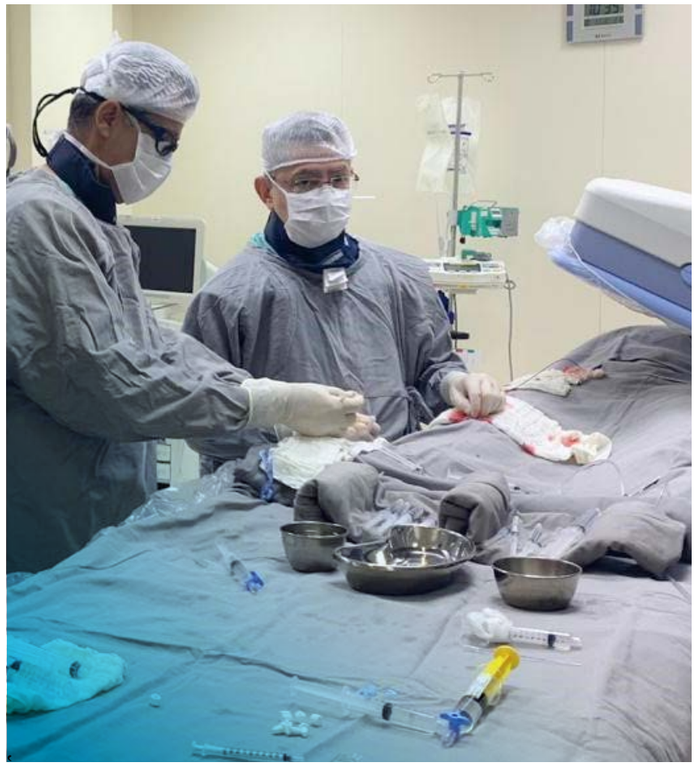
What equipment are you using for your PAE cases at Hospital Das Clinicas of the University of Sao Paulo Medical School?

Pr Francisco Cesar Carnevale: *"In our institution, we work on a GE Innova 4100-IQ system which has been upgraded early 2019 with Vessel ASSIST[4]. This solution allows pelvic and prostatic vascular anatomy segmentation from CBCT and 3D augmented fluoroscopy."*

Can you share your experience with the Vessel ASSIST solution for your PAE practice?

Pr Francisco Cesar Carnevale: *" In the past, several Digital Subtraction Angiographies (DSA) had to be repeated to correctly identify and characterize the internal iliac and prostatic arteries. It was cumbersome and time-consuming. Now we can switch from DSAs to cone-beam computed tomography (CBCT) to image the overall pelvic vascular anatomy. With the Vessel ASSIST solution, we can fuse the segmented 3D arteries over real-time fluoroscopy to assist the interventionalist during the catheter navigation. This has changed the way we perform PAE. With this new solution, we have reduced procedure time and radiation levels. We feel more confident in planning the procedure during the treatment. It's a new exciting era for PAE."*

Below two cases on patients presenting with BPH, enlarged prostate, suffering from disturbed urinary function, with recurrent daily and nightly urinary incontinence, abdominal pain and weakness.



Case 1

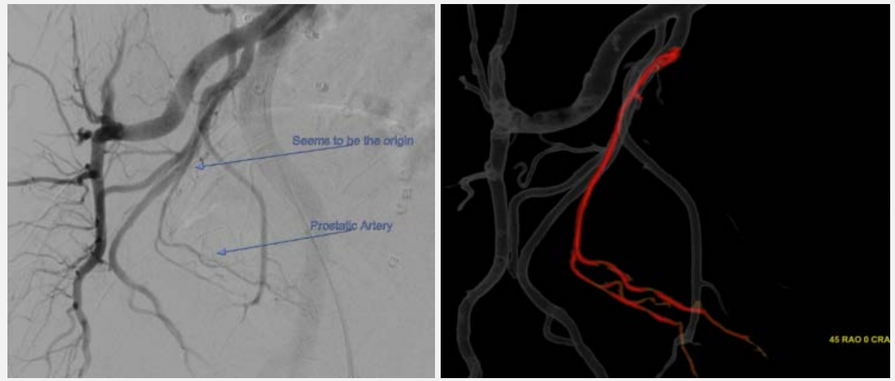


Figure 1. *57 years old male patient.* ***Left:*** *45° ipsilateral DSA showing vessels overlap hiding the prostatic artery's origin.* ***Right:*** *CBCT imaging depicting the ostia of the prostatic artery (classified in this case as Type 1 anatomical variant[6,7]).*

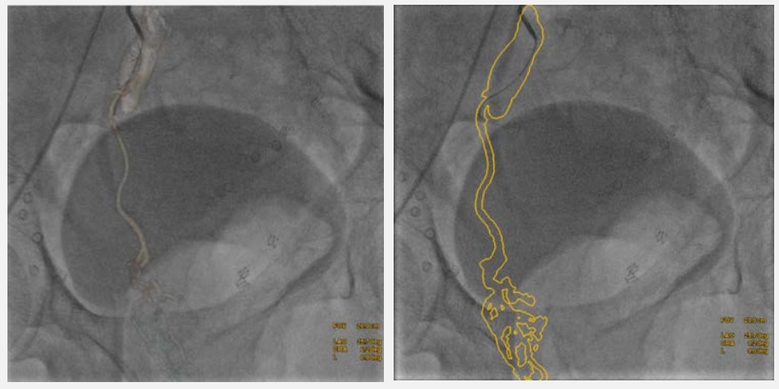


Figure 2. *Vessel ASSIST.* ***Left:*** *overlay of the segmented prostatic artery and the ostium from the right internal iliac to help navigate to the desired injection point (which will be further confirmed with distal CBCT acquisition).* ***Right:*** *outline rendering can be helpful to enhance catheter visualization.*

Figure 1 illustrates why 2D DSA alone is limited to accurately identify the origin of the prostatic artery. In our experience, it is often necessary to acquire a second or even a third DSA. A CBCT 3D image provides a comprehensive understanding of the vascular pelvic anatomy with a higher accuracy. This can lead to a reduction in radiation dose when compared to multiple DSAs.
As an example, in this case, the left side DSA Air Kerma was 31.5 mGy while the CBCT Air Kerma was 52.8 mGy.
Without the CBCT, one or two additional DSAs would have been needed resulting in a total of 63 mGy or 95 mGy. In this scenario, CBCT allowed a dose reduction of 16% to 44%[5].

Case 2

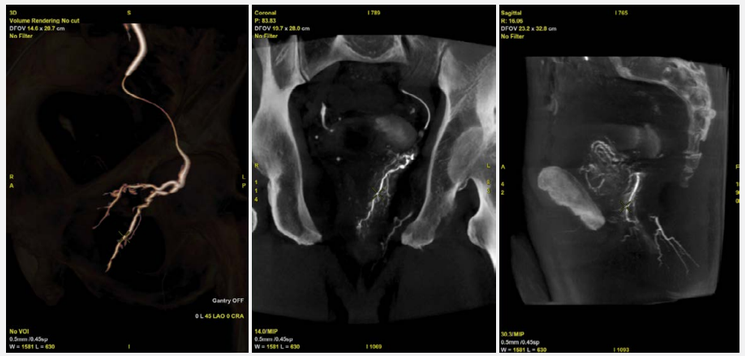


Figure 3. Left Prostatic Artery: Selective CBCT helped depict a rectal branch. To avoid risks of non-target embolization, a coil was deployed to protect the rectum. ***Left:*** *Volume Rendering,* ***Middle:*** *Coronal view,* ***Right:*** *Sagittal view.*

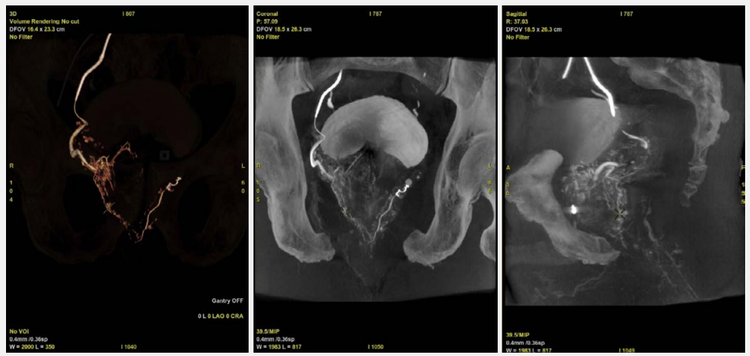


Figure 4. Right Prostatic Artery. A vessel going to the rectum was detected and a protection coil was placed similarly to the left side. ***Left:*** *Volume Rendering,* ***Middle:*** *Coronal view,* ***Right:*** *Sagittal view.*

Conclusions:

"When dealing with complex vascular anatomies such as the pelvic vasculature, multiple DSAs are usually necessary to identify small arteries origin and connections. This contributes to an increased radiation dose, contrast media injection and procedure time. Based on our experience, CBCT is sufficient and the best tool to characterize the vasculature and identify the prostatic arteries, and can be used instead of multiple DSAs. In our experience, this practice is associated with a dose reduction of approximately 30%."

Pr Carnevale's main takeaways:

- *Based on our experience, CBCT acquisition overcomes the limitation of the projective nature of 2D DSAs.*
- *Vessel ASSIST provides 3D visualization and segmentation of vessels. In our practice, it is key for efficient identification of prostatic arteries, their origins and connections to other organs.*
- *Vessel ASSIST provides real time fusion of 3D prostatic arteries with fluoroscopy to augment live imaging during the catheterization.*
- *We experience a significant dose reduction when using CBCT and Vessel ASSIST, in substitution of multiple DSAs.*

References

* The statements described here are Dr. Carnevale's professional opinion.

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2. Carnevale FC, Moreira AM, Antunes AA. The "PErFecTED technique": Proximal Embolization First, then Embolize Distal for benign prostatic hyperplasia. Cardiovasc Intervent Radiol 2014; 37:1602-1605.
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4. Vessel ASSIST solution includes Vision 2, VesselIQ Xpress, Autobone Xpress and requires AW workstation with Volume Viewer, Volume Viewer Innova. These applications are sold separately.
5. The Statements described here are based on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist i.e. hospital size, case mix, there can be no guarantee that other customers or patients will achieve the same results.
6. Moreira AM, de Assis AM, Carnevale FC, Antunes AA, Srougi M, Cerri GG. A Review of Adverse Events Related to Prostatic Artery Embolization for Treatment of Bladder Outlet Obstruction Due to BPH. Cardiovasc Intervent Radiol. 2017 Oct; 40(10):1490-1500.
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